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Measurements of Λ_c^+ production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ with ALICE

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Summary. — A Large Ion Collider Experiment (ALICE) has been designed to study the strongly interacting medium created in heavy-ion collisions at LHC energies, the Quark Gluon Plasma (QGP). Heavy quarks (charm and beauty), produced in the early stages of the collisions, are among the most powerful probes to study this state of matter. We report about the charmed baryon Λ_c^+ measurement in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ with the ALICE experiment, through the reconstruction of the decay channels $\Lambda_c^+ \to pK^-\pi^+$ and $\Lambda_c^+ \to p\bar{K}^0$ (and charge conjugates).

PACS `14.20.Lq` – Charmed baryons ($|C| > 0, B = 0$).

1. – Introduction

Charm and beauty quarks belong to the most powerful probes to study the Quark Gluon Plasma in heavy-ion collisions: produced in hard parton scattering processes occurring in the early stages of the collision, they traverse the QCD medium, interact with its constituents and experience the whole evolution of the medium. In particular, the Λ_c^+ measurement in Pb-Pb collisions should answer the question if the enhancement of the baryon-to-meson ratio in nucleus-nucleus collisions relative to pp collisions, observed at intermediate p_T at RHIC and LHC in the light-flavour sector, also holds in the heavy-flavour sector. Such an enhancement could point to hadron production by coalescence at intermediate momentum but also radial flow could play a role [1, 2]. The measurement in pp collisions provides the necessary baseline to understand the results in Pb-Pb collisions and it is needed, together with results for D mesons, to measure the total charm cross section.

The ALICE detector consists of a central barrel at mid-rapidity and a muon spectrometer at forward rapidity. A subset of the central barrel detectors is essential for the Λ_c^+ analysis: the Inner Tracking System (ITS) for vertex reconstruction and tracking, the Time Projection Chamber (TPC) for tracking and Particle Identification (PID) and the Time of Flight detector (TOF) for PID. Two hadronic decay channels were studied:

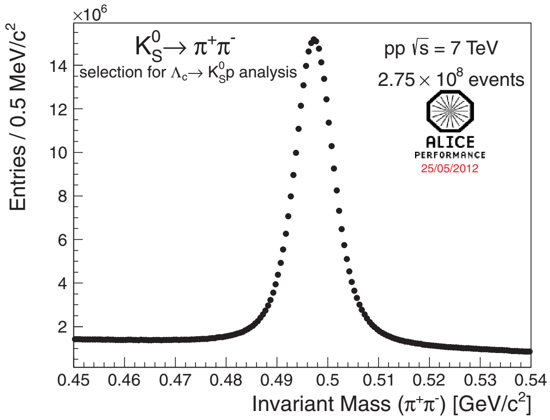

Fig. 1. – Invariant mass of K^0_S candidates.

$\Lambda_c^+ \rightarrow pK^-\pi^+$ (and charge conjugate) with a branching ratio (BR) of $(5.0 \pm 1.3)\%$(1) and $\Lambda_c^+ \rightarrow pK^0_S$ with an overall(2) branching ratio of $(0.8 \pm 0.2)\%$.

This analysis was performed on a data sample of about 3×10^8 events collected with a minimum-bias trigger(3) during the 2010 LHC run with pp collisions at $\sqrt{s} = 7\,\text{TeV}$.

2. – Λ_c^+ analysis strategy

Λ_c^+ is the lightest baryon carrying open charm, with a rest mass of $2.286\,\text{GeV}/c^2$ and a decay length ($c\tau$) of $60\,\mu$m [3]. The measurement is based on the reconstruction of displaced secondary decay vertices. For the decay channel $\Lambda_c^+ \rightarrow pK^-\pi^+$ single tracks are selected at first. Pairs of tracks with opposite charge are constructed and topological selections are applied on the vertices defined for each pair of tracks. A third track is finally attached to a pair, forming a Λ_c^+ candidate and the vertex of the triplet is calculated. The identification of pions, kaons and protons reduces the large combinatorial background: a Bayesian approach is used to combine the response of the TPC and TOF detectors. Particle species are assigned to the tracks according to the maximum probability criterion: a track is identified as species i if the Bayesian probability $W(i)$ to be of species i is the highest.

For the decay channel $\Lambda_c^+ \rightarrow pK^0_S$, pairs of tracks with opposite charge are selected in the invariant mass window of the K^0_S, applying topological selections and excluding pairs that, with the (p, π) or (e^+, e^-) mass assignments, are compatible with Λ decays or photon conversions. After this selection, the purity of the sample of K^0_S is very high (fig. 1). These K^0_S candidates are subsequently combined with single tracks originating from the interaction point, forming Λ_c^+ candidates. Protons are identified using a "number of sigma cut" approach, where the measured energy deposit (TPC) or time-of-flight (TOF) are compared with the values expected for protons.

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(1) This BR includes resonant as well as non-resonant decays with a proton, a kaon and a pion in the final state.
(2) $\Lambda_c^+ \rightarrow p\bar{K}^0$ with BR $(2.3 \pm 0.6)\%$; $\bar{K}^0 \rightarrow K^0_S$ with a probability of 50% and finally $K^0_S \rightarrow \pi^+\pi^-$ with BR $(69.20 \pm 0.05)\%$.
(3) The minimum bias trigger selects all the events with at least one hit in the innermost layers of the ITS or in one of the scintillator arrays, positioned in the forward and backward regions of the experiment, in coincidence with signals from the beam pickup detectors.

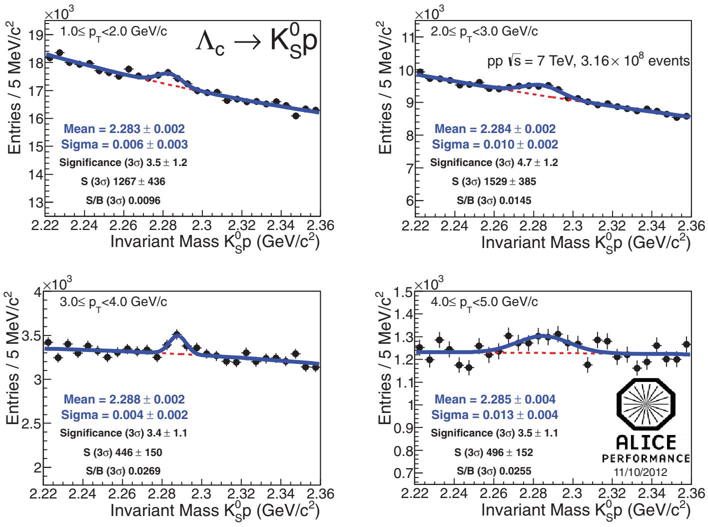

Fig. 2. – Invariant mass distribution of $\Lambda_c^+ \to pK^-\pi^+$ candidates. The signal is observed in four p_T bins in the range $2 < p_T < 6\,\mathrm{GeV}/c$.

3. – Results

A clear Λ_c^+ signal can be observed in both decay channels, as shown in figs. 2 and 3, in the p_T range $[2, 6[\,\mathrm{GeV}/c$. We are not able to observe a Λ_c^+ signal for $p_T < 1\,\mathrm{GeV}/c$, because the combinatorial background is huge and the resolution on the track position is not sufficient to separate the Λ_c^+ decay vertex from the interaction point.

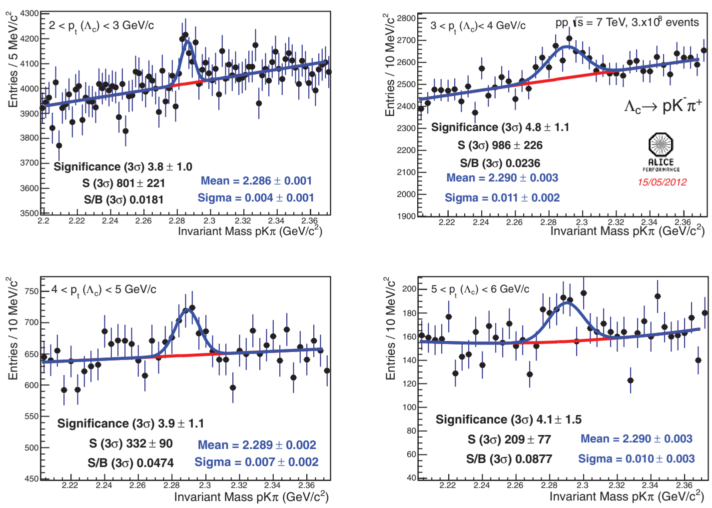

Fig. 3. – Invariant mass distribution of $\Lambda_c^+ \to pK_S^0$ candidates. The signal is observed in four p_T bins in the range $1 < p_T < 5\,\mathrm{GeV}/c$.

4. – Perspectives for future measurements

For the measurement of the Λ_c^+ production cross section, corrections for reconstruction and selection efficiency and detector acceptance need to be applied. These are the next steps of this analysis.

As was demonstrated, the Λ_c^+ analysis in *pp* collisions is strongly limited by the large combinatorial background. The larger statistics, which will be available with the increase in luminosity expected during Run II, will improve the precision of our results.

The observation of Λ_c^+ in Pb-Pb collisions is very challenging with the present detector. However, the ITS upgrade (planned for the second long LHC shutdown in the years 2018-2019) [4] will improve the track impact parameter resolution (by a factor of ~ 3), the tracking efficiency and p_T resolution at low p_T. These new features will enable us to measure Λ_c^+ for the first time in Pb-Pb collisions.

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